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(71) Applicant and

(72) Inventor: GILLEN, Glenn, P. [US/US]; 4425 Wade Drive, Metairie, LA 70003 (US).

(74) Agents: NEHRBASS, Seth, M. et al.; 3 Lakeway Center, Suite 3290, 3838 North Causeway Boulevard, Metairie, LA 70002 (US).

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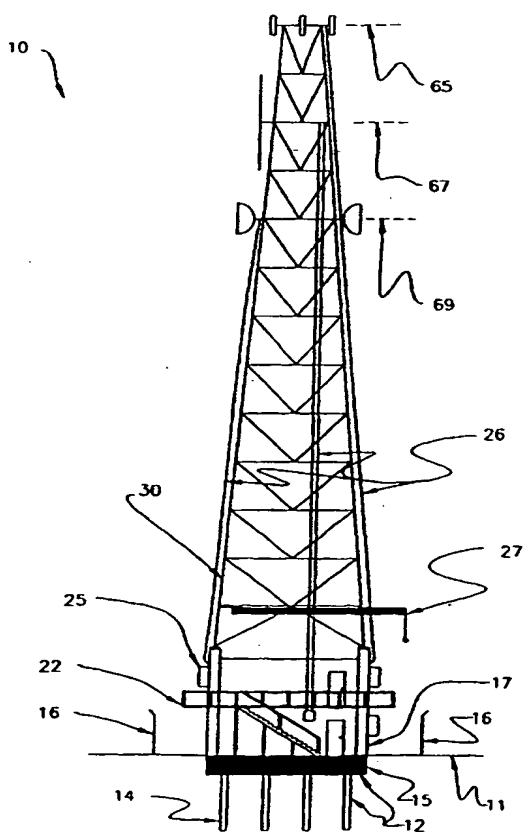
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(54) Title: ANTENNA TOWER AND SUPPORT APPARATUS



(57) Abstract: An antenna tower and support apparatus (10) includes a foundation (12) and a building mounted on the foundation (12), the building including a plurality of vertically spaced apart building sections (preferably two, three or more)(18, 20), a bottom and a top. A tower (44) is supported upon the top of the building. A plurality of antenna are attached at multiple elevational positions (65, 67, 69). Each building section (18, 20) has a security area that is separate from the security area of the other building sections. A plurality of antenna portals are provided at least one on each building section (18, 20). A plurality of antenna cables (26) are provided, each cable extending from an antenna to a security area of a building section via an antenna portal, wherein each security area has at least one antenna cable (26) that extends to it. Each security area has telecommunications equipment that is connected to one of the antenna cables (26).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

PATENT APPLICATION

TITLE OF THE INVENTION

"ANTENNA TOWER AND SUPPORT APPARATUS"

5 INVENTOR(S): GILLEN, Glenn, P., a US citizen, of 4425 Wade Drive, Metairie,
Louisiana 70003, US

CROSS-REFERENCE TO RELATED APPLICATIONS

US Patent Application No. 09/545,985, filed 10 April 2000, is incorporated herein
by reference.

10 In the US only, priority is claimed to US Patent Application No. 09/545,985, filed
10 April 2000.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

15 REFERENCE TO A "MICROFICHE APPENDIX"

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

20 The present invention relates to tall tower and building arrangements where used
for structural and electronic support of antenna. Even more particularly, the present
invention relates to an improved antenna tower and support apparatus that features an
improved configuration of multiple equipment rooms, multiple sets of antenna cable, and
multiple sets of antennae at different elevations on a tower.

2. General Background of the Invention

25 Very tall towers are typically used to support one or more antennae at desired
elevational positions. One of the most common usages of such a tower is in the cellular
telephone industry. Other examples of such antenna supporting towers include radio,
pagers, television, and two-way radio.

30 One of the means of defraying the expense of constructing such a tall antenna
supporting tower is to provide multiple users with multiple electronic support/equipment
rooms. This provision of multiple rooms and multiple sets of antenna associated with a

single tower can present security problems. It is to this problem that the present invention is directed.

Numerous patents have issued that are directed to very tall towers which support either a single antenna or multiple antennae. Examples of such patents are contained in the following table:

Prior Art Patents

| Patent # | Title | Issue Date |
|-----------|--|---------------|
| 1,116,111 | Station for the Transmission and reception of Electromagnetic Wave Energy | November 1914 |
| 3,768,016 | Modular, Prefabricated, Integrated Communications Relay Tower | October 1973 |
| 4,899,500 | CMR Cell Site | February 1990 |
| 4,912,893 | Transportable CMR Cell Site | April 1990 |
| 5,162,807 | Architectural Structure Combining At Least One Antenna With Supporting Mast Positioned on the Ground and at Least One High-Power Transmitter | November 1992 |
| 5,200,759 | Telecommunications Tower Equipment Housing | April 1993 |
| 5,581,958 | Pole and Cabinet Structure for Antenna-Mounting at Communications Site | December 1996 |
| 5,904,004 | Integrated Communications Equipment Enclosure and Antenna Tower | May 1999 |
| 5,969,693 | Multi-User Antenna Telecommunication Tower | October 1999 |

BRIEF SUMMARY OF THE INVENTION

The present invention provides an improved antenna tower and support apparatus that include both structural support for the antenna and its tower as well as telecommunications support via equipment and cabling.

The apparatus includes a foundation which can include piling, if necessary. A building is mounted on the foundation including a plurality of vertically spaced apart

building sections (for example, two or three). The building itself includes a bottom that is next to the foundation and a top that is next to the tower.

5 A tower is supported upon the top of the building. This support can be in the form of legs of the tower that rest upon the tops of columns provided at intervals around the periphery of the building.

A plurality of antennae are attached to the tower at multiple elevational positions.

Each building section has a security area that is separate from the security area of other building sections.

10 A plurality of antenna portals are provided, at least one being provided on each building section and preferably communicating with a security area of a building section.

A plurality of antenna cables are provided that extend between the building and the various antennae. Each cable extends preferably from an antenna to a security area of a building via an antenna portal. Each security area has at least one antenna cable that extends to it and each security area has telecommunication equipment that is connected
15 to one of the antenna cables.

The tower can be a self-supporting tower, a guyed tower, or a monopole. The tower can be a guyed tower that is guyed to the top of the building or to the surrounding terrain using appropriate anchors that are embedded in the earth.

20 At least one of the building sections has multiple antenna cable that enter its security area via an antenna portal.

The multiple antenna can include at least one microwave antenna, one whip antenna and/or one panel antenna. In some installations, the multiple antennae include different types of antennae placed at different elevational positions such as, for example, one microwave antenna and at least one panel antenna placed at different elevational
25 positions.

The apparatus further comprises a single ground ring that is grounded below the earth's surface next to the building. The ground ring is preferably in the form of a ring that extends circumferentially around the foundation of the building, embedded in the earth.

30 The present invention thus provides an improved building, tower and antenna arrangement that does not require ice bridges, transformer foundations, or electrical

backboard foundations.

The system of the present invention reduces uplift forces at ground level, thus reducing or eliminating the need for deep foundations.

5 The system of the present invention reduces the required length of tower because of the use of multiple building sections to elevate the lower end portion of the tower.

The system of the present invention reduces construction time and costs for future carriers/users.

The system of the present invention reduces land requirements, fencing, stone or gravel requirements and shortens fall radius of the tower.

10 BRIEF DESCRIPTION OF THE DRAWINGS

For a further understanding of the nature, objects, and advantages of the present invention, reference should be made to the following detailed description, read in conjunction with the following drawings, wherein like reference numerals denote like elements and wherein:

15 Figures 1 and 1A are elevation views of the preferred embodiment of the apparatus of the present invention;

Figure 2 is a fragmentary, elevation view of an alternate embodiment of the apparatus of the present invention;

20 Figure 3 is a fragmentary view of the preferred embodiment of the apparatus of the present invention illustrating the connection between columns associated with different of the various buildings;

Figure 4 is a partial, elevation exploded view illustrating the optional 3 building sections that occupy different elevational positions;

Figure 5 is a schematic plan view of a typical prior art tower and building layout;

25 Figure 6 is a plan view of the preferred embodiment of the apparatus of the present invention;

Figure 7A-7D are plan views of alternate tower constructions that can be used as part of the apparatus of the present invention;

30 Figure 8 is a fragmentary view illustrating a floor plan for one of the building section portions of the preferred embodiment of the apparatus of the present invention; and

Figure 9 is another partial plan view of a building section of the preferred embodiment of the apparatus of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Figures 1, 1A, 6, 7A-7D and 8-9 show the preferred embodiment of the apparatus of the present invention, designated generally by the numeral 10 in Figures 1 and 1A. Antenna tower and support apparatus 10 is shown in its position relative to the earth's surface 11 in Figures 1 and 1A. The antenna tower and support apparatus 10 includes a building foundation 12 that can include a plurality of piling 14 (optional) and a foundation cap 15.

A building ground ring 13 with ground rods 70 (commercially available) is provided near the building foundation 12, as shown in Figures 1A and 6, 7A-7D. Other optional equipment includes fence 16, stairway 21 and balcony 22 with handrails. A lower elevational building section 18 is supported within tower base 17. The tower base 17 is preferably an extension of the foundation cap 15, all of which can be, for example, reinforced concrete.

A plurality of building sections 18, 20, 31 are optionally provided one atop the other. When these three building sections 18, 20, 31 are assembled together, they provide foundation columns 19 connecting the building sections together and can be used for supporting tower 30. Columns 19 transfer load between tower 30 and foundation 12. Tower 30 is preferably a self-supporting tower as shown in Figures 1 and 1A, but can be any of the tower constructions shown in Figures 7A-7D as will be explained more fully hereinafter.

The building sections 18, 20, 31 preferably include a lower elevation building section 18, an upper elevation building section 20, and optionally, a third floor building section 31. In Figures 1-1A, the building sections share a common floor/ceiling. For example, the ceiling for lower section 18 is the floor slab for the upper section 20. Each of the building sections 18, 20, 31 has one or more doors 23, one or more cable access ports 24, as well as one or more HVAC (heating, ventilation, and air conditioning) units 25.

Antenna cable 26 is used to interface each of the building sections 18, 20 and 31 with antennae 64, 66, 68 respectively. The tower 30 can be provided with a hoist 27.

The surrounding earth 11 can provide a stone, asphalt or concrete apron 28, fence 16 and gate 29.

5 A column support arrangement is provided for defining an interface between the various building sections 18, 20, 31, the building foundation 12, and in some situations, the tower such as self-supporting tower 30. Lower building column 32 is shown in Figures 3 and 4 as being connected (preferably bolted) to a second floor building column 33. In situations wherein three building sections (three floors) are provided, a third floor building column 34 is provided. As shown in Figures 2-4, these building columns 32, 33, 34 can be bolted together using bolted connections 37. However, one piece columns 19
10 (e.g., Concrete or steel) can be used in place of the column sections 32, 33, 34.

In Figure 2, an alternate construction, designated as 10A is shown wherein the position of the tower 30 is shown in dotted lines, depending upon whether there are two floors or three floors. The tower position is indicated as 35 wherein two building sections (two floors) are provided. The tower position is indicated by the numeral 36 wherein
15 there are three building sections 18, 20, 31 (three floors). In figures 2, 3 column sections 32, 33, 34 are bolted together.

In the plan view of Figure 6, the aligned building columns 19 or 32, 33, 34 are arranged around the periphery of the building that is defined by the three building sections 18, 20 31. In Figure 6, the self supporting triangularly shaped tower 30 is shown
20 for purposes of illustration.

In Figures 7A-7D, other tower arrangements are shown that can be used keeping with the method and apparatus of the present invention. In Figure 7A, a guyed tower 60 is shown supported upon column 59. The columns 59 can be centered but does not have to be. A corner column 19 can be used. Guy wires extend beyond the fence 16 to
25 anchors (not shown) such as for example piling that are driven into the earth for holding the guy wire 61.

In Figure 7B, a self-supporting tower 62 is shown which is similar to the tower 30, but which is rectangular or square in cross section as shown in Figure 7B.

In Figure 7C, a monopole 63 arrangement is provided wherein one or more
30 monopoles 63 sit upon respective columns 59 (only one is shown for purposes of clarity). In Figure 7C, the monopole 63 is self-supporting.

In Figure 7D, a guyed tower is shown similar to the embodiment of Figure 7A. The same column 59 and tower 60 are shown in Figure 7D. The guy wires 61 however, are attached to columns 19, rather than to the earth as with the embodiment of Figure 7A.

5 Floor plans are shown in Figures 8 and 9 as exemplary for each of the different building sections 18, 20, 31. In Figure 8, four different equipment rooms 41 are shown, each having telecommunications equipment 39 to which is connected an interior cable 38. The interior cable 38 is connected to the exterior antenna cable 26 that travels up the tower (such as tower 30) for connection to the selected antenna 64, 66, 68. Interior walls 40 separate the rooms 41.

10 In Figure 9, two equipment rooms 42 are shown separated by walls 40.

In Figure 5, an existing, prior art tower and building system is shown, designated generally by the numeral 43. Tower 44 is supported upon a tower foundation 45. A tower ground ring 46 surrounds tower foundation 45. A building ground ring 47 surrounds each building equipment pad 48, 49, 50, 51. In the existing prior art shown in Figure 5, four
15 separate buildings (or equipment cabinets) 52, 53, 54, 55 are supported respectively by separate equipment pads 48, 49, 50, 51. Each of these pads requires its own ground ring 47.

In the prior art example of Figure 5, ice bridges 56 are used to cover cabling that extends from each of the separate buildings or equipment cabinets 52-55 to tower 44.
20 Electrical backboard foundation 57 and transformer pad foundation 58 are also shown in Figure 5.

A third embodiment of the apparatus of the present invention could be provided to provide a building that is of a single level as opposed to the two and three and four level constructions that are discussed above. In the third embodiment, the single building
25 would support the tower such as a self-supporting tower or any of the towers in figures 7A - 7D. However, the single building would provide multiple secured areas such as for example, 2, 4 or 6 rooms separated by permanent walls. In the third embodiment, each secured area (room) has its own antenna portal through the exterior wall of the building, its own antenna cabling, and its own set of antennae at a selected elevational position.
30 In other words, each secured area or room has its own set of antennae at its own elevational position on the common tower.

The following is a list of reference numeral used in the instant application:

LIST OF REFERENCE NUMERALS

| | Reference Numeral | Description |
|----|-------------------|-------------------------------------|
| | 10 | antenna tower and support apparatus |
| 5 | 10A | antenna tower and support apparatus |
| | 11 | earth's surface |
| | 12 | building foundation |
| | 13 | building ground ring |
| | 14 | piling |
| 10 | 15 | foundation cap |
| | 16 | fence |
| | 17 | tower base |
| | 18 | lower elevation building section |
| | 19 | column |
| 15 | 20 | upper elevation building section |
| | 21 | stairway |
| | 22 | balcony |
| | 23 | door |
| | 24 | cable access port |
| 20 | 25 | hvac unit |
| | 26 | antenna cable |
| | 27 | hoist |
| | 28 | apron |
| | 29 | gate |
| 25 | 30 | three-sided self supporting tower |
| | 31 | third floor building section |
| | 32 | lower building column |
| | 33 | second floor building column |
| | 34 | third floor building column |
| 30 | 35 | tower position (two floors) |
| | 36 | tower position (three floors) |

| | | |
|----|----|----------------------------------|
| | 37 | bolted connection |
| | 38 | interior cable |
| | 39 | telecommunication equipment |
| | 40 | interior wall |
| 5 | 41 | equipment room |
| | 42 | equipment room |
| | 43 | tower and building system |
| | 44 | tower |
| | 45 | tower foundation |
| 10 | 46 | tower ground ring |
| | 47 | building ground ring |
| | 48 | equipment pad |
| | 49 | equipment pad |
| | 50 | equipment pad |
| 15 | 51 | equipment pad |
| | 52 | building/equipment cabinet |
| | 53 | building/equipment cabinet |
| | 54 | building/equipment cabinet |
| | 55 | building/equipment cabinet |
| 20 | 56 | ice bridge |
| | 57 | electrical backboard foundation |
| | 58 | transformer pad foundation |
| | 59 | column |
| | 60 | guy tower |
| 25 | 61 | guy wire |
| | 62 | four-sided self supporting tower |
| | 63 | monopole |
| | 64 | panel antenna |
| | 65 | elevational position |
| 30 | 66 | whip antenna |
| | 67 | elevational position |

68 microwave dish antenna
69 elevational position
70 ground rod

The foregoing embodiments are presented by way of example only; the scope of
5 the present invention is to be limited only by the following claims.

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CLAIMS

1. An antenna tower and support apparatus, comprising:
 - a) a foundation;
 - b) a multistory building mounted on the foundation, including a plurality of
5 vertically spaced apart building sections that include at least a bottom section and a top section;
 - c) a tower supported upon the top of the building;
 - d) a plurality of antennae attached to the tower;
 - e) a plurality of the building sections having a security area that is separate
10 from the security area of other building sections;
 - f) a plurality of antenna portals, at least one antenna portal being provided on each building section;
 - g) a plurality of antenna cables, each security area having a cable extending from an antenna to the security area via an antenna portal; and
15 h) a plurality of the security areas having telecommunication equipment that is connected respectively to one of said antenna cables.
2. The antenna tower and support apparatus of claim 1 wherein the tower is a self supporting tower.
3. The antenna tower and support apparatus of claim 1 wherein the tower is
20 a guyed tower.
4. The antenna tower and support apparatus of claim 1 wherein the tower is a monopole tower.
5. The antenna tower and support apparatus of claim 1 wherein the tower is a guyed tower that is guyed to the top of the building.
- 25 6. The antenna tower and support apparatus of claim 1 wherein at least one of the building sections has multiple antenna cables that enter its security area via an antenna portal.
7. The antenna tower and support apparatus of claim 1 wherein the multiple antenna include at least one microwave antenna.
- 30 8. The antenna tower and support apparatus of claim 1 wherein the multiple antennae include at least one whip antenna.

9. The antenna tower and support apparatus of claim 1 wherein the multiple antennae include at least one panel antenna.
10. The antenna tower and support apparatus of claim 1 wherein the multiple antenna include at least one microwave antenna and at least one panel antenna.
- 5 11. The antenna tower and support apparatus of claim 1 wherein the multiple antenna include at least one microwave antenna and at least one whip antenna.
12. The antenna tower and support apparatus of claim 1 wherein the multiple antenna include at least one whip antenna and at least one panel antenna.
13. The antenna tower and support apparatus of claim 1 further comprising
10 a single ground ring grounded below the earth's surface next to the building.
14. The antenna tower and support apparatus of claim 13 wherein multiple of the building sections have connections to the ground ring.
15. The antenna tower and support apparatus of claim 14 wherein each building has electronic equipment that is grounded to the ground ring.
- 15 16. The antenna tower and support apparatus of claim 14 wherein each building has metallic equipment that is grounded to the ground ring.
17. An antenna tower and support apparatus, comprising:
- a) a foundation;
- b) a multilevel building mounted on the foundation, including a plurality of
20 vertically spaced apart building sections, that include at least a bottom section and a top section, and a plurality of load bearing columns that span vertically from the bottom to the top;
- c) a tower supported upon the top of the building;
- d) a plurality of antenna attached to the tower;
- 25 e) a plurality of the building sections having a security area that is separate from the security area of other building sections;
- f) a plurality of antenna portals provided on multiple of the building sections;
- g) an antenna cable extending from an antenna to a security area via an
30 antenna portal for a plurality of the building sections; and
- h) a plurality of the security areas having telecommunication equipment that

is connected to an antenna cable.

18. The antenna tower and support apparatus of claim 15 wherein the columns each comprise connected together vertical column sections.

19. The antenna tower and support apparatus of claim 15 wherein the tower
5 has tower legs, each leg of the tower supported by a column.

20. The antenna tower and support apparatus of claim 15 wherein the tower is a self supporting tower.

21. The antenna tower and support apparatus of claim 15 wherein the tower is a guyed tower.

10 22. The antenna tower and support apparatus of claim 15 wherein the tower is a monopole tower.

23. The antenna tower and support apparatus of claim 15 wherein at least one of the building sections has multiple antennae cable that enter its security area via an antennae portal.

15 24. The antenna tower and support apparatus of claim 15 wherein the multiple antennae include at least one microwave antenna.

25. The antenna tower and support apparatus of claim 15 wherein the multiple antennae include at least one whip antenna.

20 26. The antenna tower and support apparatus of claim 15 wherein the multiple antennae include at least one panel antenna.

27. The antenna tower and support apparatus of claim 15 wherein the multiple antennae include at least one microwave antenna and at least one panel antenna.

28. The antenna tower and support apparatus of claim 15 wherein the multiple antennae include at least one microwave antenna and at least one whip antenna.

25 29. The antenna tower and support apparatus of claim 15 wherein the multiple antennae include at least one whip antenna and at least one panel antenna.

30. The antenna tower and support apparatus of claim 15 further comprising a single ground ring grounded below the earth's surface next to the building.

30 31. The antenna tower and support apparatus of claim 30 wherein multiple of the building sections have connections to the ground ring.

32. An antenna tower and support apparatus, comprising:

- a) a foundation;
 - b) a multistory building mounted on the foundation, including a plurality of vertically spaced apart building sections that include at least a bottom section positioned next to the foundation and a top section, each building section defining a separate floor of the multistory building;
 - 5 c) an open tower supported upon the multistory building and above the top section, the tower comprising only exposed structural connecting members and not being covered, enabling wind load to be minimized;
 - d) a plurality of antennas attached to the tower at multiple elevational positions;
 - 10 e) a plurality of the building sections having a security area that is separate from the security area of another building section;
 - f) an antenna portal provided on each of the plurality of building sections;
 - g) a plurality of antenna cables, a cable extending from an antenna to a security area of a building section via an antenna portal, wherein a plurality of the security areas have at least one antenna cable that extends to it; and
 - 15 h) a plurality of the security areas having telecommunication equipment that is connected to one of said antenna cables.
33. The antenna tower and support apparatus of claim 32 wherein the open tower is a self supporting tower.
- 20 34. The antenna tower and support apparatus of claim 32 wherein the open tower is a guyed tower.
35. The antenna tower and support apparatus of claim 32 wherein the open tower is a monopole tower.
- 25 36. The antenna tower and support apparatus of claim 32 wherein the open tower is a guyed tower that is guyed to the top of the building.
37. The antenna tower and support apparatus of claim 32 wherein at least one of the building sections has multiple antenna cables that enter its security area via an antenna portal.
- 30 38. The antenna tower and support apparatus of claim 32 wherein the multiple antennas include at least one microwave antenna.

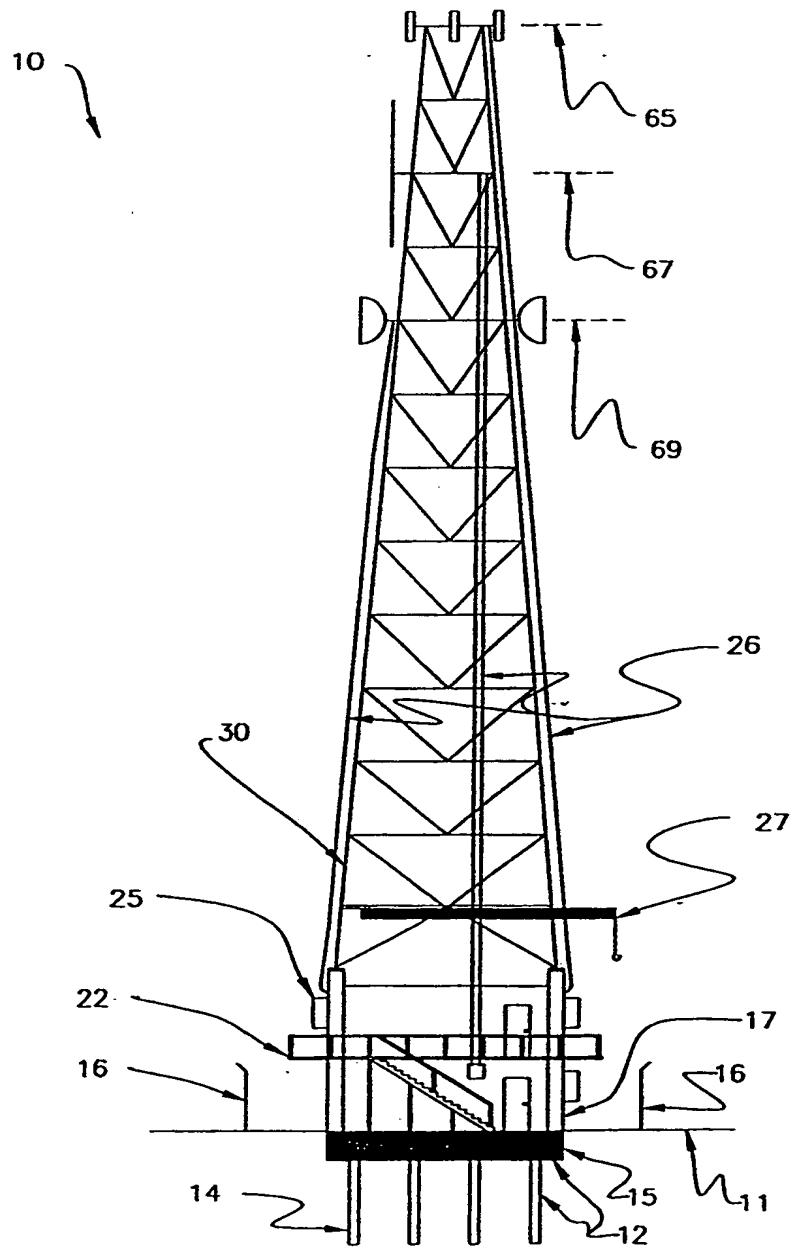
39. The antenna tower and support apparatus of claim 32 wherein the multiple antennas include at least one whip antenna.
40. The antenna tower and support apparatus of claim 32 wherein the multiple antennas include at least one panel antenna.
- 5 41. The antenna tower and support apparatus of claim 32 wherein the multiple antennas include at least one microwave antenna and at least one panel antenna.
42. The antenna tower and support apparatus of claim 32 wherein the multiple antennas include at least one microwave antenna and at least one whip antenna.
43. The antenna tower and support apparatus of claim 1 wherein the multiple
10 antennas include at least one whip antenna and at least one panel antenna.
44. The antenna tower and support apparatus of claim 3 further comprising a single ground ring grounded below the earth's surface next to the building.
45. The antenna tower and support apparatus of claim 34 wherein multiple of the building sections have connections to the ground ring.
- 15 46. The antenna tower and support apparatus of claim 45 wherein each building has electronic equipment that is grounded to the ground ring.
47. The antenna tower and support apparatus of claim 45 wherein each building has metallic equipment that is grounded to the ground ring.
48. An antenna tower and support apparatus, comprising:
- 20 a) a foundation;
- b) a multistory building mounted on the foundation, the building including a plurality of vertically spaced apart building sections that include at least a bottom building section positioned next to the foundation and a top building section,
- c) a plurality of load bearing columns that span vertically from the bottom
25 section to the top section;
- d) a tower supported upon the top section of the building;
- e) a plurality of antennas attached to the tower at multiple elevational positions;
- f) each building section defining a separate floor of the multistory building,
30 a plurality of the building sections each having a security area that is separate from the security area of other building sections;

g) antenna portals provided on a plurality of the building sections;
h) a plurality of antenna cables, an antenna cable extending from an antenna to a security area of a building section via an antenna portal for a plurality of the building sections; and

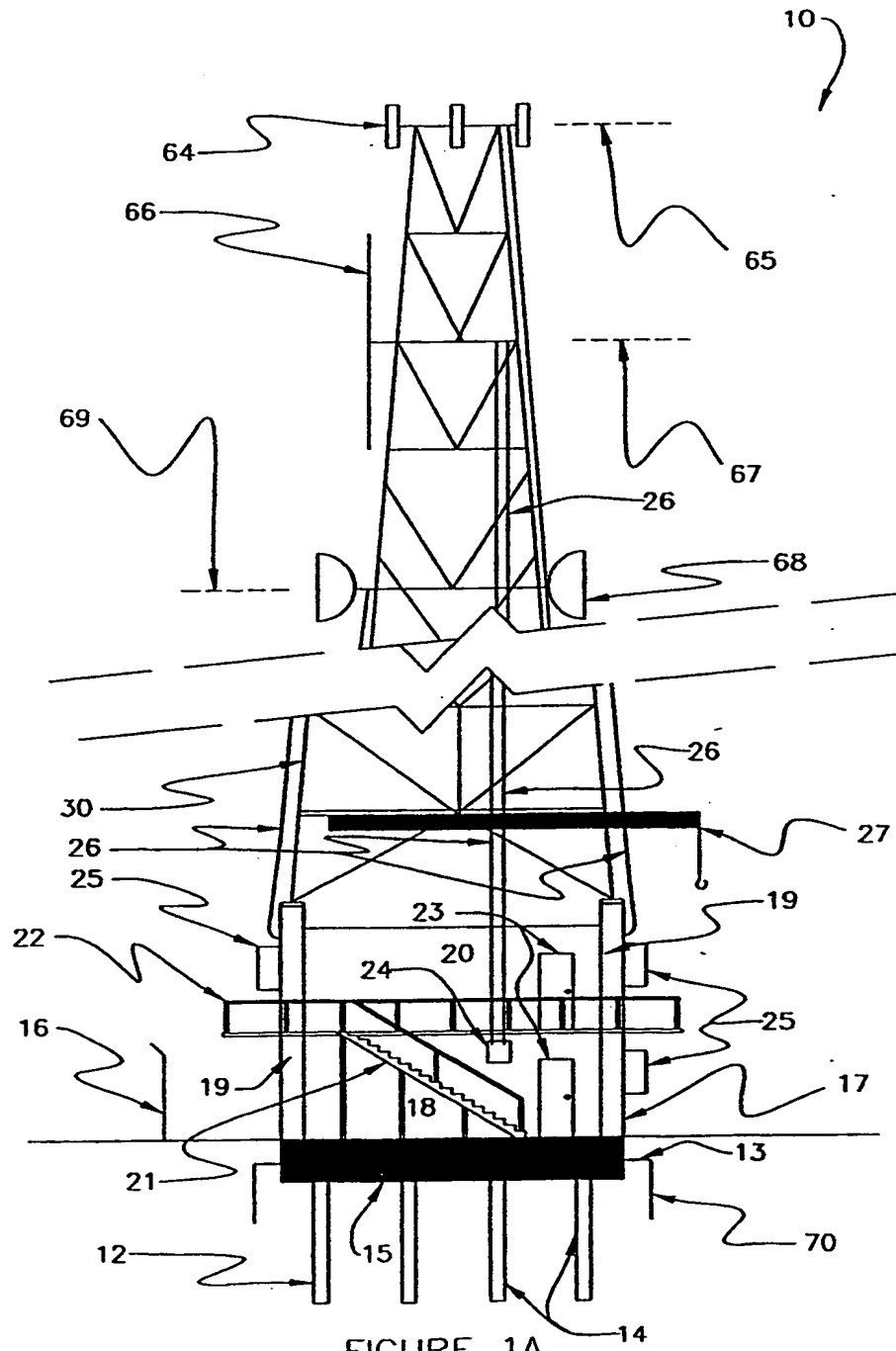
5 i) a plurality of the security areas having telecommunication equipment that is connected to on of said antenna cables.

49. The antenna tower and support apparatus of claim 48 wherein the columns each comprise connected together vertical column sections.

50. The antenna tower and support apparatus of claim 48 wherein the tower
10 has tower legs, each leg of the tower supported by a column.



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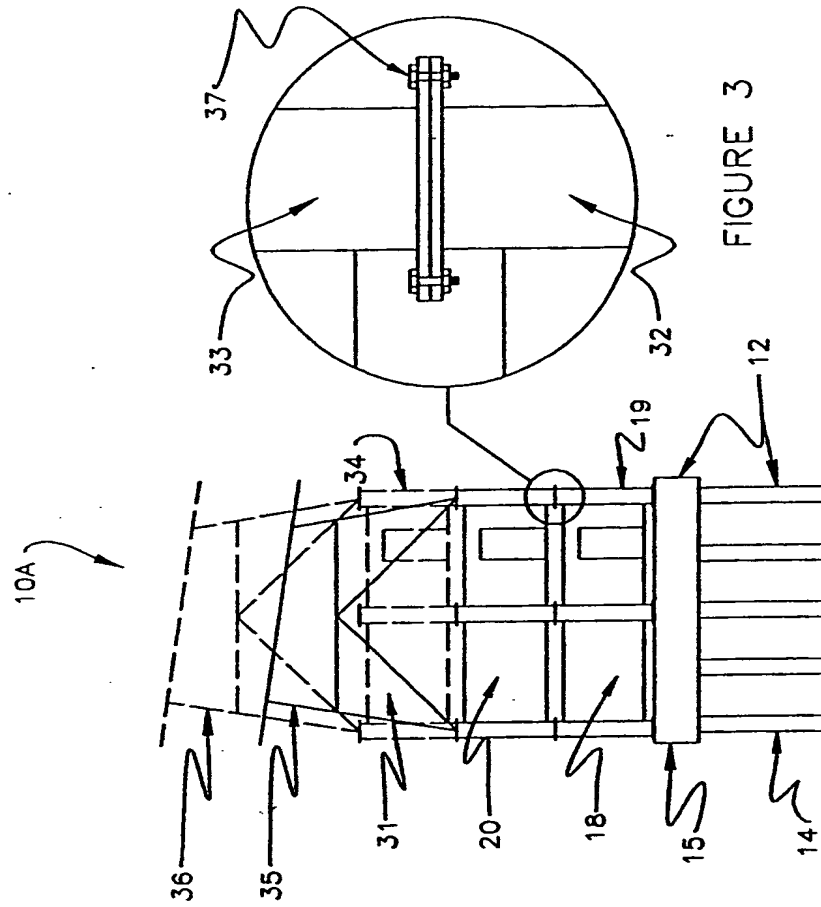


FIGURE 2

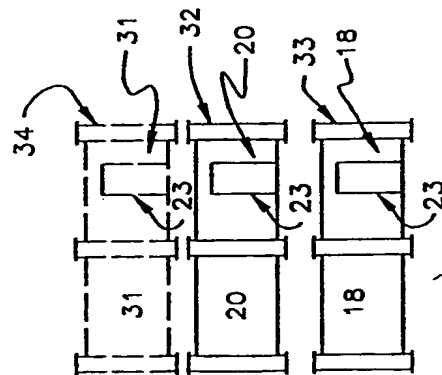


FIGURE 4

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FIGURE 5 – EXISTING PRIOR ART

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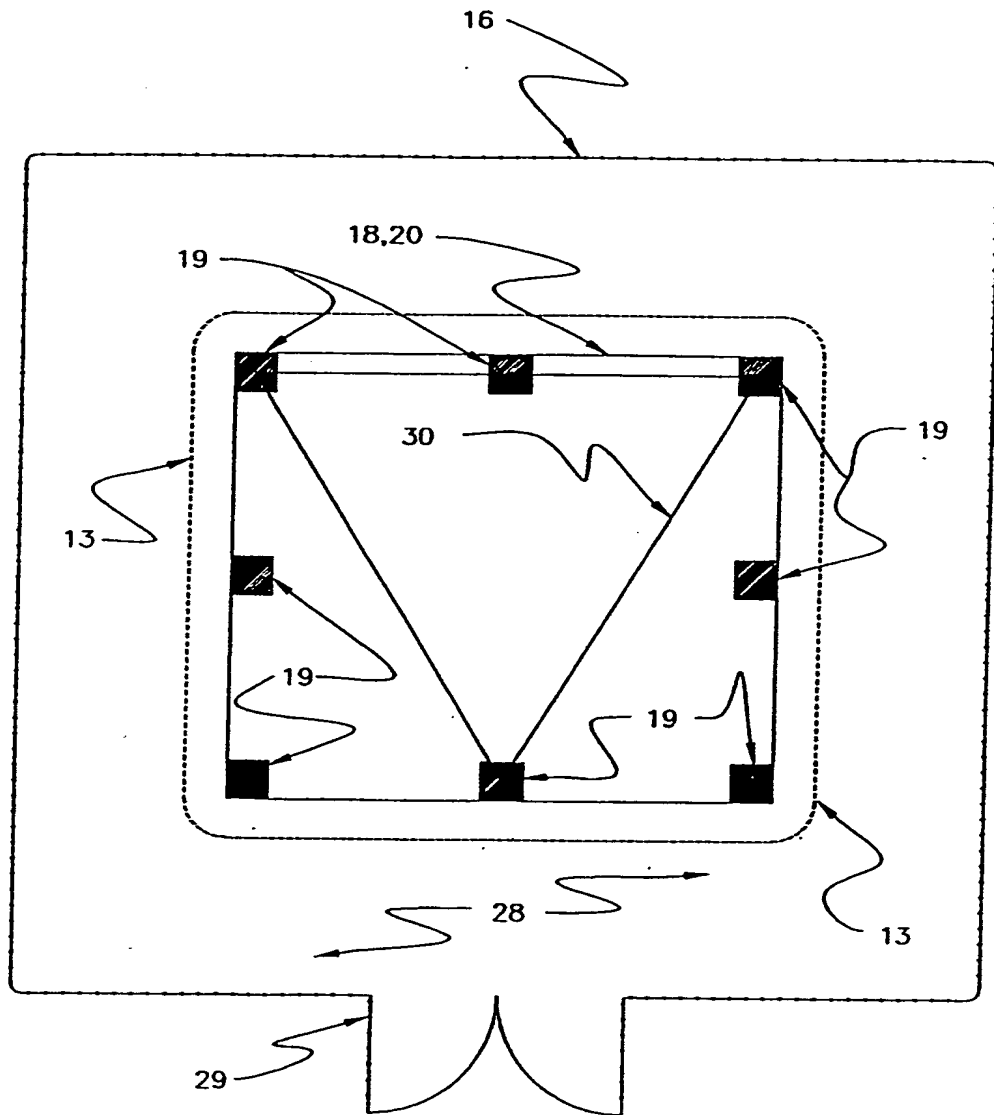


FIGURE 6

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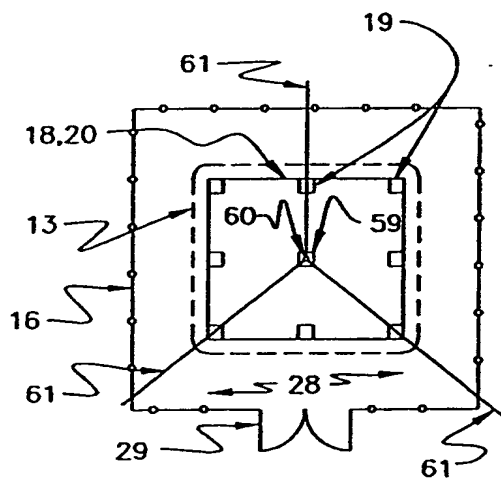


FIGURE 7A

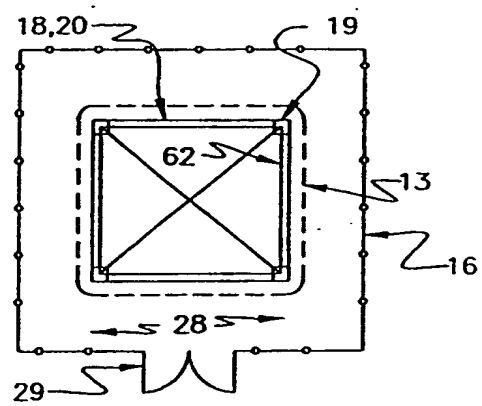


FIGURE 7B

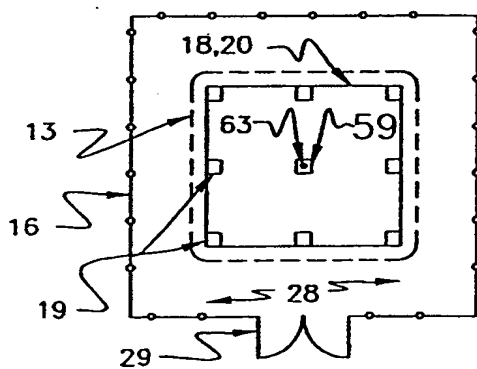


FIGURE 7C

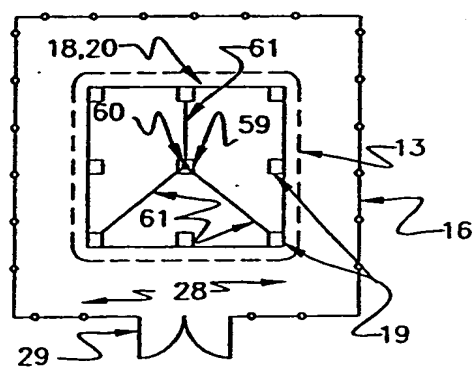


FIGURE 7D

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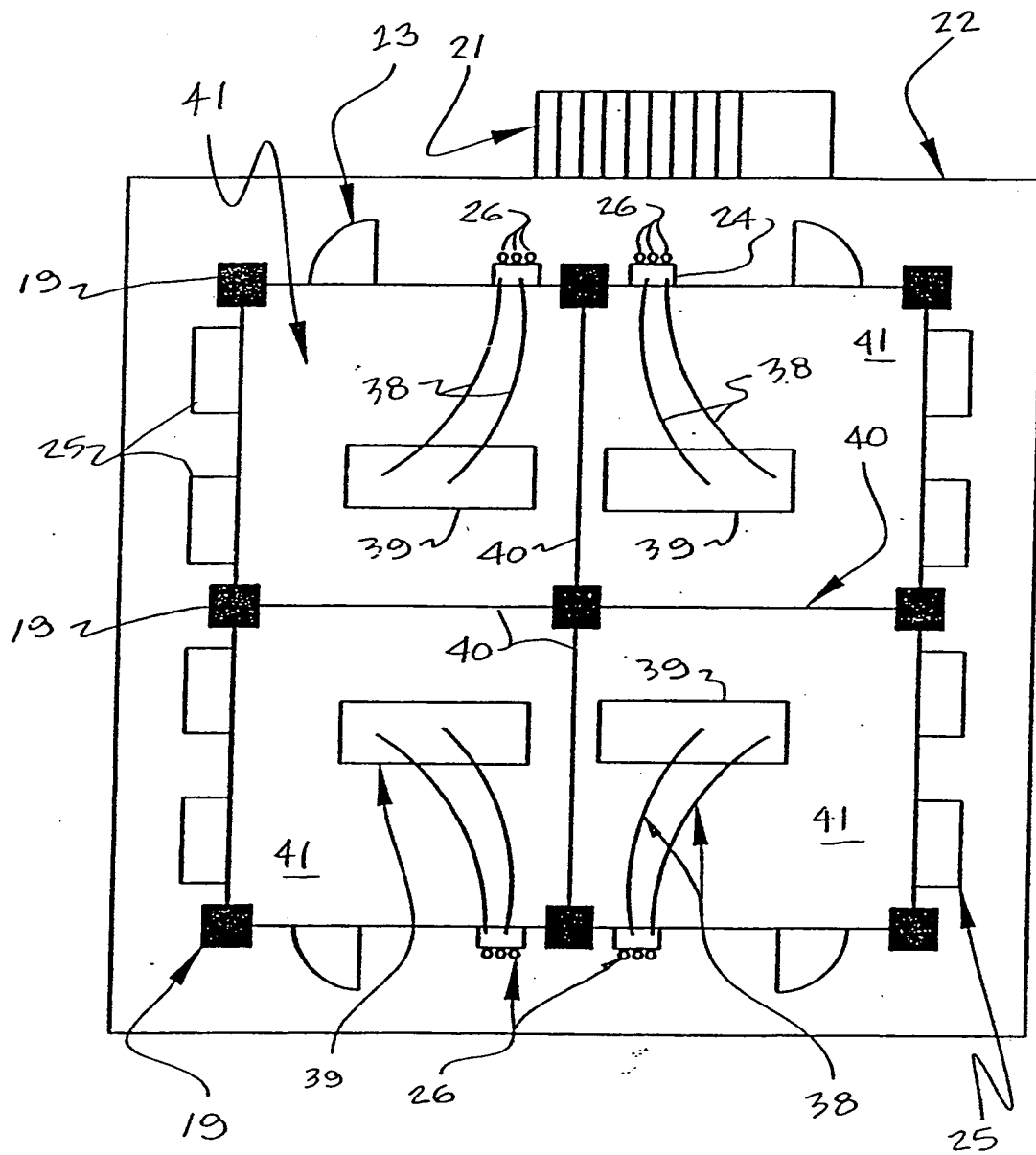


FIGURE 8

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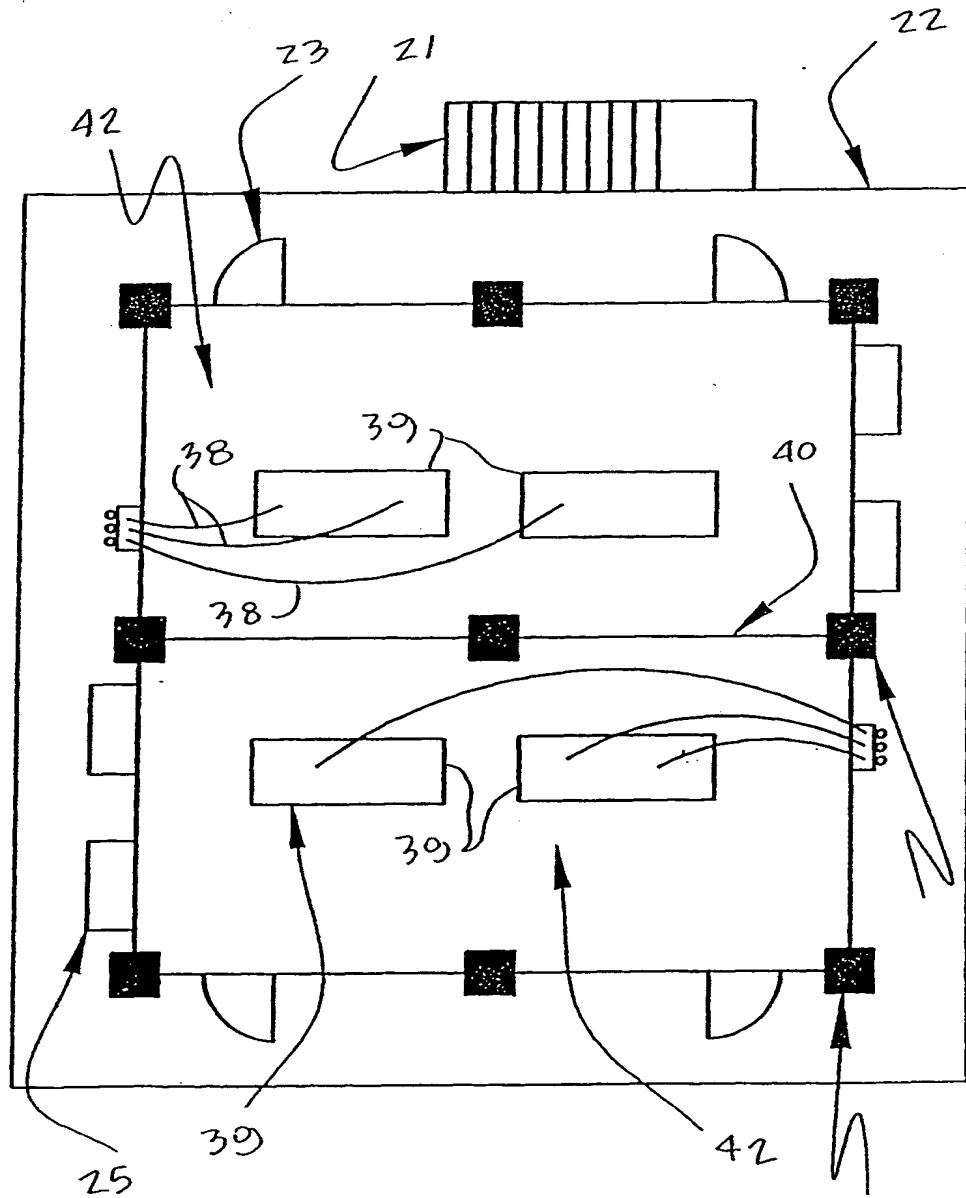


FIGURE 2

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/05552

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H01Q 1/12

US CL : 343/890; 52/40

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 343/890, 872, 891; 52/40, 111, 651.07

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
~~NONE~~Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
USPTO APS EAST, WEST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| Y | US 5,904,004 A (HILL) 18 May 1999 (18.05.1999), fig. 1. | 1-50 |
| Y | US 4,912,893 A (MILLER et al) 03 April 1990 (03.04.1990), fig. 1. | 1-50 |
| Y | US 5,969,693 A (LEGG) 19 October 1999 (19.10.1999), fig. 2. | 1-50 |
| Y | US 5,911,117 A (BHAME et al) 08 June 1999 (08.06.1999), figs. 6 and 8. | 1-50 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

| | |
|---|--|
| * Special categories of cited documents: | "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
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| "P" document published prior to the international filing date but later than the priority date claimed | |

Date of the actual completion of the international search
05 JUNE 2002

Date of mailing of the international search report

15 JUL 2002

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Authorized officer

JAMES CLINGER

Facsimile No. (703) 305-3230

Telephone No. (703) 305-0619

Reese R. Hunter

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